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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

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October 6, 1994

DOGM
MINERALS PROGRAM
FILE COPY

Greg Hawkins
Mine Manager
Brush Wellman, Inc.
P.O. Box 815
Delta, Utah 84624

Re: Mine Plan Reclamation Variance and Release Requests, Brush Wellman Inc., Topaz Mining Property, M/23/003, Juab County, Utah

Dear Mr. Hawkins:

This letter is sent in response to your January 28, 1994 and July 29, 1994 letters, which seek formal Division approval of specific mine plan reclamation variance and revegetation release requests. The Division conducted a field inspection of the mine properties on September 8, 1994. We evaluated the results of the second reseeding efforts on the upper Rainbow and North Blue Chalk dumps during the inspection. As stipulated in the Division's September 10, 1992 letter, *a variance is hereby granted for the upper portions of the Rainbow and North Blue Chalk dumps*.

Your letters also request a release for reclamation work performed within the Sigma Emma and Taurus areas. Specifically, a release has been requested for the safety berm construction and road reclamation in these areas. We observed these berms and road conditions during our inspection and hereby grant *a release for the safety berm construction surrounding the Sigma Emma and Taurus pits.* However, due to lack of adequate revegetation, a release cannot be granted at this time for the roads in both areas. Due to erosion on the road, the Division recommends the construction of several waterbars along the portion of road east of the Sigma Emma pit. We have enclosed some references that could be used to assist you in designing and spacing water bars. Scarifying compacted areas and reseeding of both roads may help facilitate future revegetation success.

During the September 8th inspection, you expressed a *verbal* request for release of the safety berm construction at the Roadside #3, Section 16 North #1 pits and the Roadside #1 & #2 backfill area. *A release for the safety berm construction for these areas is granted*. As indicated in Brush Wellman's 1992 Annual Report of

Mining Operations, the Roadside #1 & #2 backfill area was seeded in 1992. The Division will not consider releasing this area until the vegetation has survived at least three growing seasons.

You pointed out during our inspection, the voluntary, supplemental reclamation work performed by Brush Wellman on the north Roadside #1 & #2 dumps. The Division commends the company for "going the extra mile" and reworking this area, especially when there was no apparent regulatory requirement to do so. We thank you for your continued cooperation and patience in resolving these permitting issues. If you have any further questions in this regard, please contact me or Travis Jones at your convenience.

Sincerely,

Travis Jones

for D. Wayne Hedberg
Permit Supervisor
Minerals Regulatory Program

jb
cc: Rody Cox, BLM
Lowell Braxton, DOGM
M023003.var

Runoff volume calculation:

A curve number of 85 is selected for a gravel road with moderate infiltration capacity (Table 2.20 - HSG B). Runoff volume, Q, is determined to be 2.6 in. (Figure 2.26, P. = 4.2, CN = 85).

Peak runoff rate:

Time lag is estimated from equation 2.60 for each selected spacing.

$$t_L = \frac{L^{0.8}\,(S+1)^{0.7}}{1900\,Y^{0.5}}, \quad S = \frac{1000}{CN} - 10 = 1.76$$

for L = 200 ft

$$t_L = \frac{(200)^{0.8}\,(1.76+1)^{0.7}}{1900\,(.08)^{0.5}} = 0.26 \text{ hr}$$

Time of concentration is approximated by equation 2.59:

$$t_c = t_L/0.6 = 0.26/0.6 = 0.43 \text{ hr.}$$

Peak flow rate, q_p, can be estimated from equation 2.70 and Figure 2.40:

$$q_p = q'_p\,A\,Q = (550)\,(.000215)\,(2.6) = 0.31 \text{ cfs}$$

A = (spacing length) (road width)

for 200 ft spacing and 30 ft road width

$$A = \frac{6000 \text{ ft}^2}{(43{,}560)\,(640)} = .000215 \text{ mi}^2$$

Size open-top culvert:

Assume a standard size open-top timber culvert, i.e., 4" width and 6" depth fabricated from unplaned wood.

Flow capacity is determined from the continuity and Manning's equation:

$$Q = VA = \frac{1.49}{n}\,R^{2/3}\,S^{1/2}\,A$$

n = 0.013 (Table 3.1)

R = bd/(2d + b) (rectangular)

A = bd

S = .02

b = 4 in = 1/3 ft

d = 1/2 ft

$$Q = \frac{1.49}{0.013}\left(\frac{(0.33)\,(0.5)}{2(0.5)+0.33}\right)^{2/3}(.02)^{1/2}\,(1/3)\,(1/2)$$

Q = 0.67 cfs

Thus, a standard designed wood open-top culvert placed across the road a two percent slope can adequately convey the peak storm runoff from a ro 30 ft in width and 200 ft long. The standard 4 in by 6 in culvert will be u lized in all calculations.

Sediment Loss:

Average annual sediment loss from the road surface will be calculated t the USLE.

R = 165 (Figure 5.3)

K = 0.24 (Table 5.6)

LS = 1.4 (Figure 5.15, L = 200, S = .08)

CP = 1.3 (Table 5.A.1., compacted bulldozer scraped up and down)

A = 0.138 ac

Y = ARKLSCP = (0.138)(165)(0.24)(1.4)(1.3) = 9.9 tons

Sediment yield for alternative water bar spacings are listed below:

Spacing (ft.)	Yield (tons)	Yield (tons/1000 linear ft.
50	1.24	24.8
100	3.54	35.4
150	6.38	42.5
200	9.93	49.7
250	13.83	55.3

sents greater than a seven-fold increase in transport capacity (Laursen, 1958). Thus, a significant quantity of sediment will be transported through the diversion to downstream sediment controls. The interrelationship between sediment control efficiency and cost among various large-scale and small-scale sediment control devices is currently under study (Warner, 1981a).

Water Bars

Function and Use

Properly designed, installed, and maintained water bars have proven to be effective drainage and sediment controls. Water bars are constructed across the road surface at specified intervals related to the road gradient. A water bar prevents storm runoff from eroding large quantities of sediment on heavily travelled or abandoned access or haul roads. By separating the erodible road surface into a series of small drainages, storm runoff and associated sediment loads are reduced. The water bar performs the basic functions of a diversion, i.e., interception and conveyance of runoff to a stabilized area and reduction of overland flow length.

A log type water bar, as illustrated in Figure 7.7, is normally used on an active road, whereas the ditch and earth berm constructior is often installed prior to road abandonment.

ign

The design of a log type water bar, open-top culvert, is shown in Figur · 7.7. The spacing between water bars is often related to the road gradient. Typical recommended spacings are shown in Figure 7.11.

An alternative to using these suggested spacings is to design water bar separations as a function of a design storm, road surface erodibility, and slope gradient. A design methodology is shown in Example Problem 7.4.

EXAMPLE PROBLEM 7.4

An access road is constructed of a sandy loam covered with fine to moderately fine gravel. Average road gradient is eight percent. The road is located in Eas-

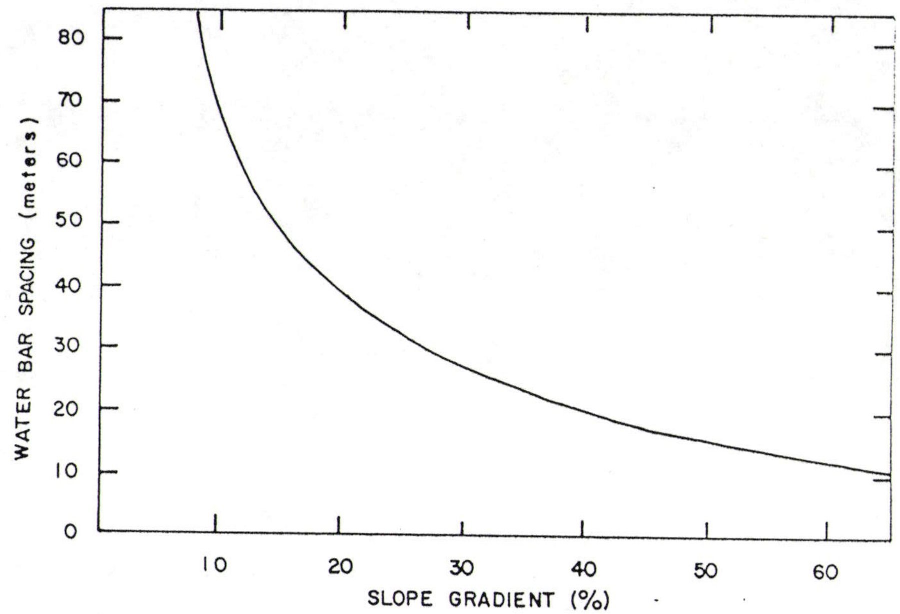


Figure 7.11. Maximum water bar spacing for various slope gradients. (adapted from White and Franks, 1978)

tern Kentucky. Use an open-top timber culvert type water bar. What is the effect of water bar spacing on the sediment loss from the access road?

Solution sequence:

Select spacing
Design storm selection
Calculate volume of runoff
Calculate peak flow rate
Size water bar for peak flow conveyance
Determine sediment loss
Repeat for alternative spacing

Spacing of open-top culverts:

Assume initial length of 200 ft.

Design storm selection:

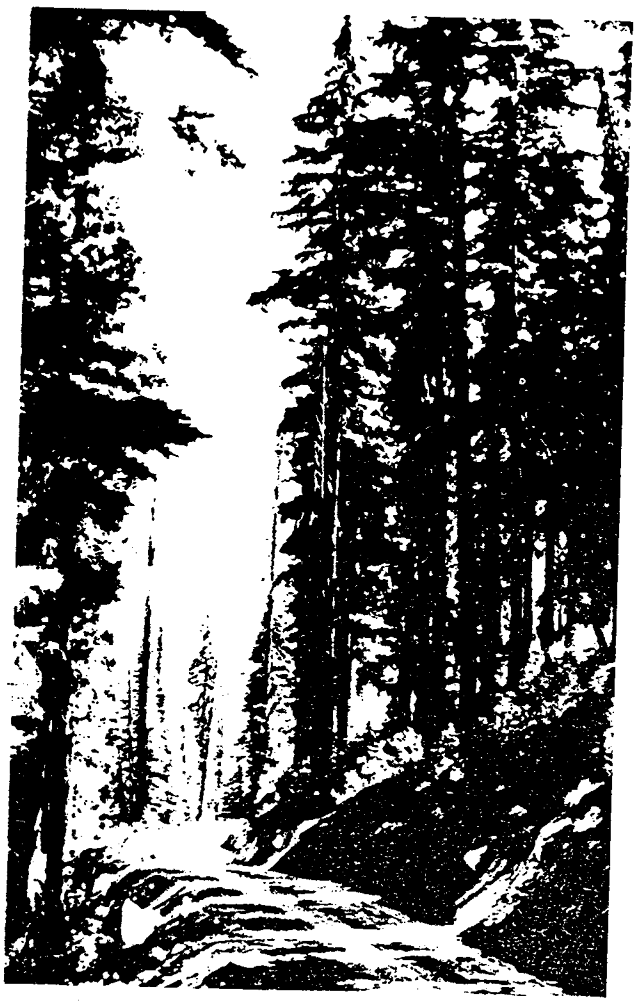
Design storm assumed to be 10-year, 24-hour, for Eastern Kentucky is 4.2 in (Sheet 3 of Appendix 2.A.2).

GUIDES FOR CONTROLLING SEDIMENT FROM SECONDARY LOGGING ROADS

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATI(
OGDEN, UTAH

and

NORTHERN REGION
MISSOULA, MONTANA



ROAD SURFACES AND MOVEMENT OF SEDIMENT

Recent earch by the Intermountain Forest and Range Experiment Station indicates that the surfaces of secondary logging roads deteriorate rapidly when rills are allowed to erode deeper than about 1 inch (fig. 1).

The distances that water flows down road surfaces before eroding rills to 1-inch depth determine what spacings are required between cross drains on road surfaces to prevent such erosion. The distances that sediment moves downslope from outlets of cross drains determine the widths of protective strips needed below roads to control sediment (fig. 2).

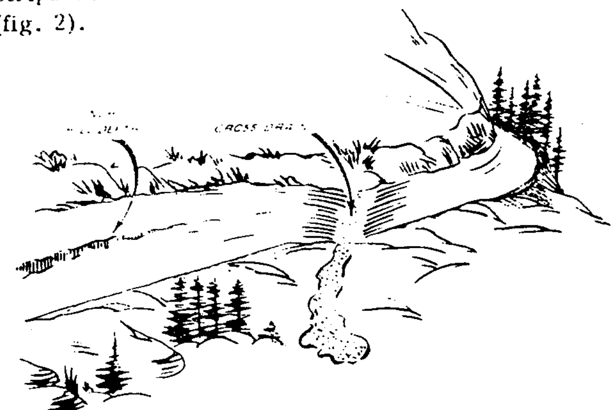


Figure 1.--Rill erosion on a road surface below a cross drain.

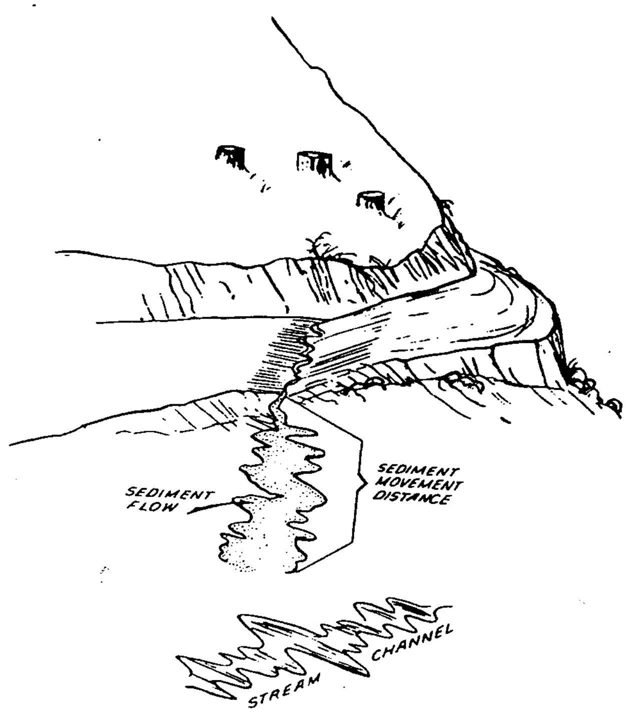


Figure 2.--Sediment movement downslope from a road cross drain.

Consequently the severity of ɨ surface erosion and the distance that sedime, oves downslope also can be controlled by applying certain preventive measures during and after roadbuilding and logging.

FIVE FACTORS AFFECT EROSION OF SURFACES OF FOREST ROADS

1. Size of soil particles

The larger the proportion of coarse soil material (larger than about 0.1 inch in diameter) on the road surface, the less likely it is to be eroded by snowmelt runoff or heavy rains. Hence, cross drains may be installed farther apart on a surface that contains mainly coarse particles than on one composed chiefly of fine particles.

The more important forest soils in the Northern Region have been classified into six groups based upon the proportion of coarse particles and water-stable aggregates larger than about 0.1 inch in diameter on road surfaces (table 1). The parent materials from which the major kinds of soil in each group were derived are also listed in table 1 as a guide to selection of the proper soil group for your later use in determining spacings of cross drains and widths of protective strips.

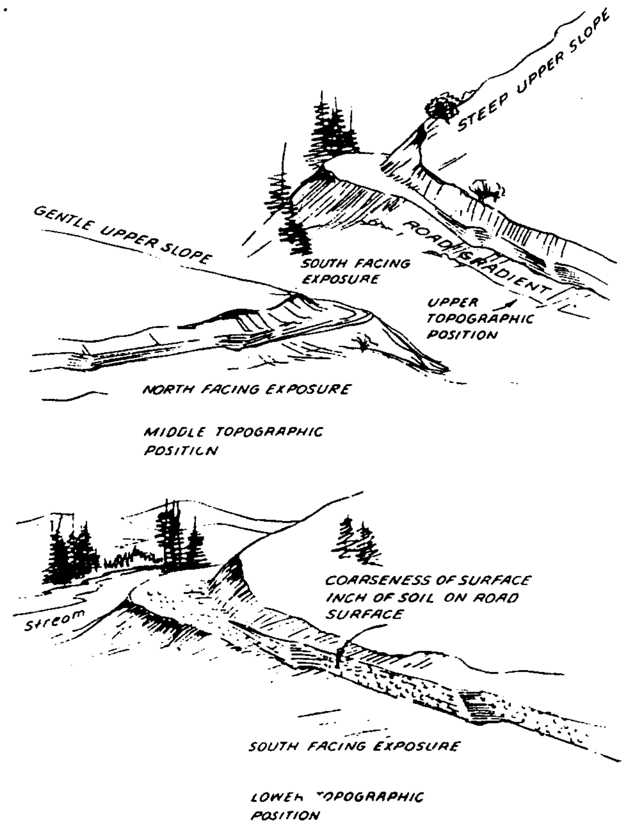


Figure 3.--Factors affecting erosion of road surface.

Table 1. Forest soil groups in order of (1) decreasing coarseness and increasing detachability of soil on road surfaces and (2) major parent materials in each group

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
decreasing coarseness and increasing detachability of road surface soil →					
hard sediments	basalt	granite	glacial silt	andesite	loess
shale (hard)	basalt porphyry	sandstone	shale (soft)	andesite porphyry	
slate	quartzite	gneiss		limestone (soft)	
argillite	conglomerate	schist			
rhyolite	gravel	sand			
rhyolite porphyry					
limestone (hard)					

2. Steepness of road grade

Since rill erosion does not occur on truly level roads, these roads need no cross drains. But as road grades get steeper, erosion increases, and cross drains must be installed closer together. Designing roads with gentle grades reduces the number of cross drains needed.

3. Topographic position

The nearer a road is to the top of a sidehill, the less the surface will wash during snowmelt runoff or a heavy rain. But if the road is near the bottom of a sidehill, cross drains will have to be spaced close together.

4. Direction of exposure

Roads on north-facing slopes are likely to erode less than those on south-facing slopes. They generally require fewer cross drains.

5. Steepness of sidehill

The steeper the sidehill across which a road is built, the wider can be the space between cross drains.

SEVEN FACTORS AFFECT MOVEMENT OF SEDIMENT BELOW SHOULDERS OF FOREST ROADS

1. Spacing of cross drains

Sediment from cross drains flows farther downslope from road shoulders when cross drains are farther apart.

2. Spacing of obstructions

Sediment flows farther down road fills and slopes below fills when obstructions that touch the ground (logs, rocks, brush, etc.) are spaced farther apart. The more closely obstructions are spaced, the narrower may be the widths of protective strips between roads and streams.

3. Kinds of obstructions

Different kinds of obstructions on fills and on slopes below fills reduce downward flow of sediment by different amounts. Obstructions that retard sediment flow, in order of decreasing effectiveness, are:

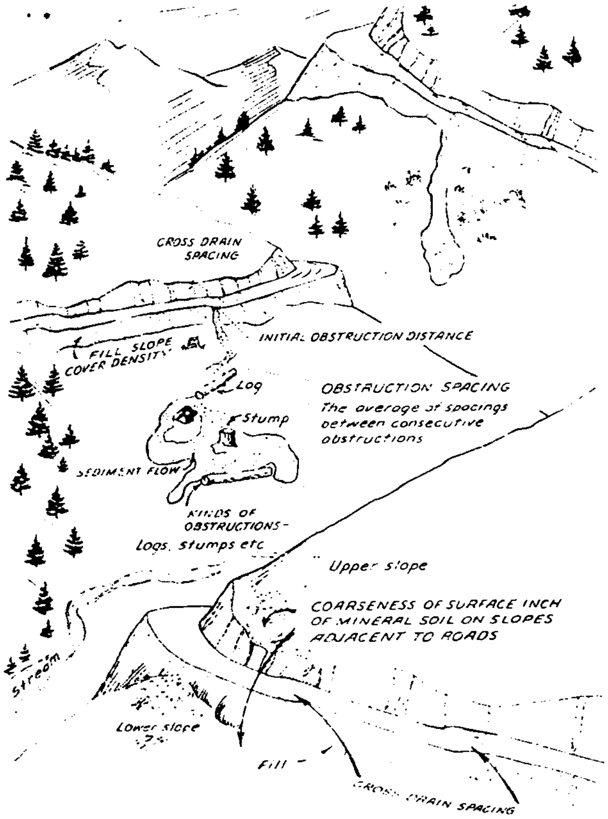


Figure 4.--Factors that affect distance sediment moves downslope.

possible on road fill slopes.

6. Siz soil particles

The size of material in the surface inch of mineral soil on slopes adjacent to logging roads is important. The smaller the size of soil particles, the farther the sediment will move.

In each of the six soil groups (table 1), the proportion of coarse soil particles and aggregates (larger than 0.1 inch in diameter) on natural slopes adjacent to roads is smaller than it is on road surfaces. This is because rainfall runoff and snowmelt have washed more of the finer soil off bare road surfaces. The order of decreasing coarseness of soil in these groups when it is on slopes adjacent to roads is also the order of increasing distance that sediment flows down slopes:

Groups 2 and 5	coarse
Group 4	moderately coarse
Groups 1 and 3	moderately fine
Group 6	fine

The difference between this order of decreasing coarseness and the order these soil groups show on road surfaces is probably due to differences in such physical characteristics of particles and aggregates as their shape and angularity, which affect the ease of their movement from road surfaces.

a. Depressions made by pushed-over or wind-thrown trees, or a wavy ground surface

b. Logs thicker than 4 inches

c. Rocks more than 4 inches wide at ground surface

d. Trees and stumps

e. Slash and brush

f. Grass, weeds, and shrubs.

This comparative list is important because it shows you can reduce the width of protective strips below roads by installing such effective obstructions as logs and rocks and spacing them reasonably close.

4. Distance to first obstruction

The closer to the outlet of a cross drain you install an obstruction, the shorter the distance that sediment will move. If the first obstruction is located at the outlet of a cross drain, the protective strip can be comparatively narrow.

5. Density of cover on fill slope

Sediment moves farther downslope as the density of ground cover decreases. Therefore,

7. Age of roads

As the age of roads increases from 1 to 3 years, the distance that sediment moves downslope from them increases slightly. As age increases to 4 and 5 years, sediment moves much farther downslope. The sudden increase in distance of sediment movement in the fourth and fifth years is due to the filling of storage capacity for sediment above the obstructions (fig. 5). This relation indicates that where the width of a protective strip is critical for preventing sediment damage to a stream, the strip can be narrower if water from cross drains is diverted toward other existing obstructions or if new obstructions are installed when the road is 3 years old.

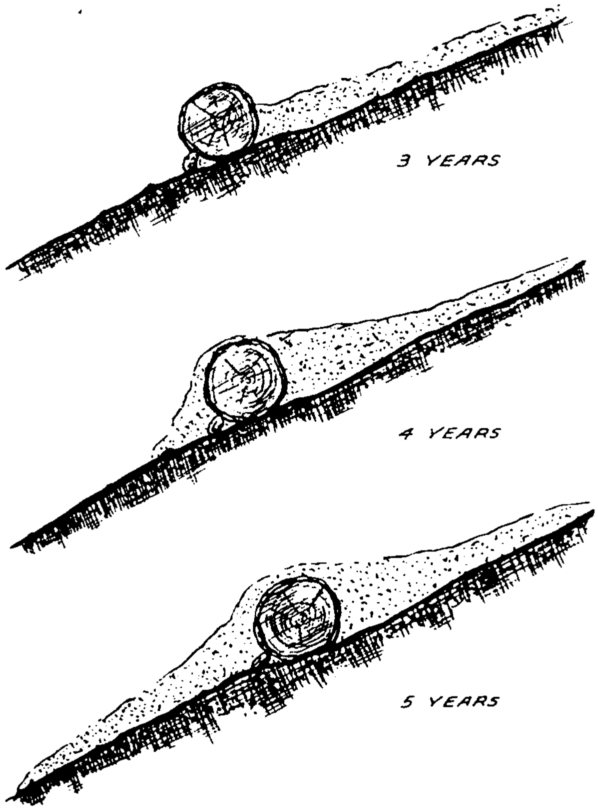


Figure 5.--Influence of age of a road on the effectiveness of obstructions for trapping sediment.

Table 2.--Cross-drain spacings[1] required to prevent rill or gully erosion deeper than 1 inch on secondary logging roads

Road grade (percent)	Soil group on which road is located or built: Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
	Cross-drain spacing (feet)					
2	167	154	137	135	105	95
4	152	139	122	120	90	80
6	144	131	114	112	82	72
8	137	124	107	105	75	65
10	128	115	98	96	66	57
12	119	106	89	87	57	48
14	108	95	78	76	46	37

[1] Table is based on location of road in the upper one-third of north-facing slopes having steepness of 80 percent.

INSTRUCTIONS:

To determine cross-drain spacings for other positions on slope, different exposures, and sidehill slope steepness less than 80 percent, apply the following instructions.

1. If road is located in the middle one-third of a slope, space 18 feet closer than shown in table 2; if it is in the bottom third of a slope, space 36 feet closer.

2. If road is located on an east or west exposure, space cross drains 8 feet closer than shown in table 2; if road is on a south slope, space 16 feet closer.

GUIDES FOR SPACING CROSS DRAINS AND DETERMINING WIDTHS OF PROTECTIVE STRIPS

The next two tables can help you determine spacings between cross drains and widths of protective strips needed for controlling sediment, provided you have some knowledge of watershed factors and of characteristics of road design.

GUIDE FOR SPACING CROSS DRAINS

Cross-drain spacings necessary to stop 83 percent of rills on road surfaces before they erode deeper than 1 inch vary according to soil type and steepness of road grade (table 2). Instructions below table 2 enable you to adjust spacing of cross drains according to differences in exposure, topographic position, and steepness of the slope above the road.

If roads are to be built in watersheds where high quality of water must be guaranteed, assurance that rills and gullies deeper than 1 inch do not develop may be increased from 83 percent to about 97 percent by reducing the spacings shown in table 2 by 45 feet. Wherever the combination of soil and topographic features requires spacing of cross drains less than about 30 feet, no logging roads should be built unless they will be surfaced with gravel or crushed rock.

3. For each 10-percent decrease in steepness of the sidehill slope from a gradient of 80 percent, space cross drains 5 feet closer than shown in table 2.

GUIDE FOR DETERMINING WIDTHS OF PROTECTIVE STRIPS

Ideally a logging road should be located far enough from a stream or other site needing protection so that sediment from the road cannot reach it. To achieve this protection, road locators allow for a strip of ground between the edge of the fill slope and the site to be protected. Minimum widths needed to achieve this protection vary according to kinds of obstructions below roads, the spacing between these obstructions, relative stability of soils, distances between cross drains, distance from cross-drain outlet to first obstruction, density of cover on the fill slope, and the periodic renewal of capacity of obstructions for storing sediment.

Minimum widths necessary to stop 83 percent of sediment flows on sites where soils are relatively stable (those derived from parent materials listed in groups 2 and 5, table 1) are shown in table 3. These widths represent total width of protective strip below the road centerline. Instructions immediately following table 3 show the amounts by which these widths must be altered to allow for differences in soil type, spacing of cross-drains, distance to first obstruction, and density of cover on the fill slope.

[illegible] required from the centerlines of roads[1] in order to prevent sediment from reaching sites needing protection

Obstruction spacing (feet)	Depressions or mounds	Logs	Rocks	Trees and stumps	Slash and brush	Herbaceous vegetation
	Width of protective strip (feet)					
1	53	55	56	58	59	61
2	55	58	61	64	67	70
3	57	61	65	70	75	79
4	58	64	70	76	82	88
5	59	66	74	81	89	96
6		68	77	86	95	104
7		70	80	91	102	112
8		71	83	95	107	119
9		72	85	99	113	126
10				103	118	133
11				106	122	139
12						145

[1]Figures in this table assume soils from groups 2 and 5, conditions of 30-foot spacing of cross drains, zero distance from cross-drain outlet to first obstruction, zero density of cover on fill slopes, and no plan to maintain capacity of obstructions for retarding and trapping sediment.

INSTRUCTIONS:

To determine protective-strip widths for soils in groups other than 2 and 5, for spacing of cross drains greater than 30 feet, for distance to first obstruction greater than zero, and for density of cover on the fill slope greater than zero, you should apply the following instructions (see example, pp. 24-25):

1. If soil is derived from group 4, increase the width of the protective strip shown in this table by 5 feet. If soil is from group 1 or 3, increase by 10 feet; if from group 6, increase by 24 feet.

2. For each 10-foot increase in spacing of cross drains beyond 30 feet (see table 2), increase width of protective strip 1 foot.

3. For each 5-foot increase in distance to first obstruction, increase width of protective strip 4 feet.

4. For each 10-percent increase in density of cover on fill slope above a density of zero, decrease width of protective strip 1 foot.

Where a logging road is proposed for construction close to a stream channel, assurance that sediment will not reach the stream can be increased to about 97 percent by increasing the protective-strip widths shown in table 3 by 30 feet.

SUPPLEMENTARY GUIDES FOR ESTIMATING WATERSHED FACTORS THAT CANNOT BE MEASURED DIRECTLY

Where logging roads are to be located, some of the watershed factors that affect the required widths of protective strips will be changed by subsequent roadbuilding and/or logging operations. The values that these factors will probably attain after road construction and/or logging will have to be estimated. The following guides have been developed to help you make these estimates.

[illegible] of plant and litter cover on fill slopes cannot be measured when the roads are being located. Hence you must estimate the density of cover to be expected after the road is built. Research has shown that cover on fill slopes remains sparse for several years on most logging roads in the Northern Region. An estimate of zero density for fill slope cover therefore appears to be safe because it will insure prescribing of adequate widths of protective strips. If fill slopes are to be seeded and mulched in the same year they are constructed, cover densities greater than zero may be justified for use in instruction 4 with table 3.

Distances to first obstructions.--Normally, few major obstructions to sediment flow occur on fill slopes. Where these slopes are chiefly loose soil, distance to the nearest obstruction depends upon the gradients of the slopes above and below the road and upon width of the road. The longest distances to the first obstruction to be expected in 97 percent of cases are shown in table 4.

Spacing of obstructions.--The different kinds of treatments that slopes below roads may receive after centerlines have been located and staked may greatly alter the spacing of obstructions. If these slopes are to be logged, expected spacing of obstructions cannot be measured before the logging operation. Logging debris may be left intact or disposed of by any of several methods involving

piling and/or burning. The degree of piling and burning usually varies with the logging operator, climatic conditions, and other factors. Consequently, the largest average spacings encountered in about 97 percent of cases for each of the six frequent types of obstructions on the study sites were selected as safe obstruction spacings because they will seldom be exceeded. These spacings are:

Obstructions	Spacing (feet)
Depressions and mounds	5
Logs	9
Rocks	9
Trees and stumps	11
Slash and brush	11
Herbaceous vegetation	12

Table 4.--Longest distances[1] from road shoulder to first obstruction for roads 12, 14, and 16 feet wide, by steepness of upper and lower slopes

Lower slope steepness (percent)	Upper slope steepness (percent): 1-20			21-40			41-60			61-80		
	Road width (feet): 12	14	16	12	14	16	12	14	16	12	14	16
10	15	15	15	16	16	16	16	16	17	17	17	17
20	16	16	16	16	17	18	17	18	19	18	19	20
30	16	17	18	17	19	20	19	20	22	20	21	23
40	16	18	20	18	21	23	21	23	25	22	24	26
50	17	19	22	19	22	25	22	25	28	24	27	30
60	17	20	23	20	24	27	24	27	31	26	29	33
70	18	21	25	22	26	29	26	29	34	28	32	36
80	18	22	27	23	28	32	28	32	37	31	35	40

[1]To be expected in 97 percent of cases.

tions remaining on slopes below ing roads depend upon characteristics of sur relief, initial cover conditions, and the kinds of logging and postlogging cleanup treatments applied to the slopes. Gentle slopes (to about 25 percent), for instance, are generally characterized by undulating or wavy topography having depressions that trap considerable sediment. Steeper slopes have fewer undulations, and depressions on them have much less capacity for stopping and storing sediment.

On timbered slopes, trees are major obstructions to movement of sediment. When these slopes are logged, obstructions are chiefly the remaining logs, stumps, and slash. Broadcast burning of logging debris eliminates most of the slash and leaves only logs and stumps. Dozer piling and burning eliminates most of the slash and logs and leaves only stumps as major obstructions to sediment flow.

Table 5 is designed to help you by listing the kinds of obstructions that usually are present on lower slopes subjected to different logging and postlogging treatments.

Table 5.--Obstructions usually found on slopes below roads by type of cover, steepness of slope, clear-cut logging treatment, and method of postlogging cleanup

Lower slope cover	Lower slope steepness	Treatment	Postlogging cleanup	Obstructions on lower slopes [2]
	Percent			
Timbered-brushy	<25	none	none	D-T-B
	<25	logged	none	D-L-S-SL-B
	<25	logged	broadcast burned	D-L-S-H
	<25	logged	dozer piled-burned	D-S-B-H
	>25	none	none	T-B
	>25	logged	none	L-S-SL-B
	>25	logged	broadcast burned	L-S-H
	>25	logged	dozer piled-burned	S-B-H
Timbered-rocky	<25	none	none	D-R-T
	<25	logged	none	D-L-R-S-SL
	<25	logged	broadcast burned	D-L-R-S-H
	<25	logged	dozer piled-burned	D-R-S-H
	>25	none	none	R-T
	>25	logged	none	L-R-S-SL
	>25	logged	broadcast burned	L-R-S-H
	>25	logged	dozer piled-burned	R-S-H

Table 5.--(con.)

Lower slope cover	Lo slope steepness	Treatment	Postlogging cleanup	Obstructions on lower slopes [2]
	Percent			
Timbered-not brushy or rocky	<25	none	none	D-T
	<25	logged	none	D-L-S-SL
	<25	logged	broadcast burned	D-L-S-H
	<25	logged	dozer piled-burned	D-S-H
	>25	none	none	T
	>25	logged	none	L-S-SL
	>25	logged	broadcast burned	L-S-H
	>25	logged	dozer piled-burned	S-H
Untimbered-brushy	<25	none	none	D-B-H
	>25	none	none	B-H
Untimbered-rocky	<25	none	none	D-R-H
	>25	none	none	R-H
Untimbered-herbaceous	<25	none	none	D-H
	>25	none	none	H

[1] D = depression; L = log; T = tree; S = stump; R = rock; SL = slash; B = brush; and H = herbaceous vegetation.

[2] In decreasing order of effectiveness for stopping sediment.

HOW TO APPLY THESE GUIDES FOR CONTROLLING EROSION AND SEDIMENT FLOW

The guides established in the previous section cannot be substituted for good judgment and experience in designing and locating logging roads. The guides are merely working tools to help you make some necessary decisions. It is assumed that anyone who uses these guides is already well acquainted with the many circumstances in road construction that may lead to serious erosion problems; hence he is alert to avoid most of them by exercising good judgment. These guides may prove useful in locating roads, in strengthening measures for controlling sediment on new roads, and in controlling sediment flow from existing roads.

LOCATING LOGGING ROADS

When these guides are used in locating a road, they furnish a checklist for determining whether any part of the road is likely to be too close to a lower lying site that needs protection from sediment. The following example illustrates how these guides can be applied to a given set of conditions. It also illustrates the flexibility possible in their application.

Determining Spacings of Cross Drains

Assume that a proposed road having a 4-

rived from hard shale. Assume further that the proposed location traverses the l one-third of the slope, which has a steepness 40 percent above the location. Soil derived from hard shale is classified in group 1 (table 1). In 83 percent of cases, an 80-foot spacing is required on soil group 1 to prevent rill and gully erosion deeper than 1 inch on the road surface (table 2).

Installation of cross drains 80 feet apart without regard for other circumstances is not implied. Obviously, if the road exposes a perennial seep, if a skid trail enters the road, or if the cross drain would fall on a deep fill section, good judgment would dictate altering the spacing.

Determining Widths of Protective Strips

In addition to the previous assumptions made about the proposed road, let us assume that the road is to be 14 feet wide, has a 30-percent slope below the centerline, and extends through a stand of timber marked for clear cutting followed by broadcast burning of the slash. Determining necessary width for the protective strip requires several preliminary steps, as follow.

Step 1. First to be determined is what kind of obstructions to sediment flow may be expected on such a site. Table 5 shows that logs are the dominant type of obstruction here.

Step 2. Greatest average spacing of these logs to be expected is 9 feet (list on p. 19).

Step 3. Under these conditions, the protective strip should be 72 feet wide (table 3).

Step 4. However, adjustment must be made for the soil type at the location, which is in group 1. Instruction 1 following table 3 shows that 10 feet must be added to the width shown in the table; this brings total width to 82 feet.

Step 5. Further adjustment must be made for the 80-foot spacing of cross drains. Instruction 2 for table 3 indicates addition of 5 more feet for a new total width of 87 feet.

Step 6. Longest distance from road shoulder to first obstruction on a 14-foot road having a 40-percent upper slope and 30-percent lower slope is 19 feet (table 4); this requires adding 16 feet to width of the strip (instruction 3 to table 3), bringing the total width to 103 feet. This width of protective strip from the centerline should contain sediment movement downslope from cross drains on this section of road.

STRENGTHENING MEASURES FOR CONTROL OF SEDIMENT

Frequently roads have to be located close to streams. You may find that certain stretches of

than the widths of protective strips needed to stop movement sediment. Under such circumstances, you may mmend use of any or all of several more intensive measures for stopping sediment safely within these narrower protective strips.

Continuing with the previous example of road location, in which the estimated required width of protective strip below the road centerline is 103 feet, assume that the actual distance from centerline to streamside is only 50 feet. The predictable sediment movement can be controlled within this 50-foot protective strip if you use the following intensive measures for control.

Step 1. You can reduce distance to the first obstruction from 19 feet to zero by scooping out depressions or installing logs at outlets of cross drains to slow the movement of all sediment and to trap some of it. This will decrease required width of the protective strip 16 feet; that is, to a width of 87 feet from centerline (table 3, instruction 3).

Step 2. Remember that protective-strip widths listed in table 3 are for roads on which it is not planned to maintain sediment storage capacity at least every 3 years. Hence, width of the protective strip in this example can be decreased another 24 feet, or to 63 feet, by installing new obstructions or by renewing storage capacity of existing obstructions when the road is no more than 3 years old.

Step 3. Spacing between obstructions can be reduced by installing additional logs between those already on the ground. Reduction of space between obstructions from 9 to 2 feet will further reduce necessary width of the protective strip 14 feet (table 3); that is, to 49 feet from centerline.

You can compute the total number of obstructions needed for any given average spacing by using the equation:

$$N = 1 + \left[\frac{(P - \frac{R}{2}) - I}{OS}\right]$$

in which
N = number of obstructions needed
P = width of protective strip from centerline
R = road width
I = distance from road shoulder to first obstruction
OS = average spacing between obstructions.

The total number of logs (N) needed to effect 2-foot obstruction spacing in this example after the initial obstruction distance has been reduced to zero is

$$1 + \frac{(49-7) - 0}{2} = 22 \text{ logs.}$$

The exact number of additional logs needed can be determined after the road is built and at the time cross drains are located; then the number of logs on the ground can be counted. U these conditions, location of the centerline of the proposed road as close as 50 feet from the stream would be safe if all the prescribed control measures were applied.

If necessary, width of the protective strip below the centerline in this example could be reduced still further by applying these additional measures for sediment control.

Step 4. Reduce spacing of the cross drains from 80 feet to 30 feet. This will reduce required width of the protective strip another 5 feet; that is, to 44 feet (table 3, instruction 2).

Step 5. Spread mulch and establish plant cover on the fill slope as soon as possible. A cover density of 70 percent, for example, will reduce required width of the strip another 7 feet, that is, to 37 feet (table 3, instruction 4).

Step 6. Reduce width of the road from 14 feet to 12 feet. This reduces required width of the strip 1 foot, or to 36 feet.

If the centerline of the road is less than 36 feet from the stream, little can be done to prevent sediment from reaching the stream. The most desirable solution in this circumstance would be to relocate the road centerline more than 36 feet from streamside. If this is not feasible, then use these

measures for decreasing the protective strip width from 103 to 36 feet; at least this will greatly reduce the amount of sediment that will reach the stream.

CONTROLLING SEDIMENT ON EXISTING ROADS

Where logging roads have been located and built without benefit of guides for location and construction, the guides developed in this study may be applied to determine whether sediment from cross drains can be controlled adequately by existing protective strips below these roads. You can determine this by computing the width of the strip required under existing watershed and road conditions and then comparing this width with the actual width of the existing strip. The following example illustrates the application of these principles.

Assume that a 16-foot logging road having a 2-percent grade has been built on loessial soil across a north-facing slope 100 feet above a small stream. Assume further that the gradients of the slopes above and below the road are 60 percent and 50 percent, respectively, and that the lower slope is covered by a dense stand of timber not scheduled for cutting.

Step 1. Note that loess is in soil group 6 (table 1).

Step 2. Enter table 2 for 2-percent road grade, soil group 6, north exposure, lowest one-third slope po n, and 60-percent upper slope steepness. this combination, cross-drain spacing of no more than 49 feet is required.

Step 3. Stake the cross-drain locations, using good judgment to insure that, insofar as possible, the drains empty onto stable fill sections on or below which standing trees are obstructions. Consider and establish each cross-drain location individually.

Step 4. Determine the distance to the first obstruction in either of two ways. One is to estimate this distance (from table 4), which is 28 feet for the road and slope conditions assumed in this example. The other is to measure or estimate the distance along a 2-foot-wide transect oriented directly downslope from the staked location of the cross-drain outlet to the nearest major obstruction. Assume, for this example, that the measured distance to the nearest obstruction is 13 feet.

Step 5. Determine the spacing between obstructions in either of two ways. One is to select the approximate maximum spacing distance (tabulation on p. 19); in this example it is 11 feet for trees. The other is to extend the 2-foot-wide transect across the existing protective strip to the edge of the stream, recording the number of trees you encounter along the transect. You can then compute the average spacing of trees by using the equation:

$$OS = \left[\frac{T-I}{N-1}\right]$$

in which
- OS = obstruction spacing
- T = total transect length downslope from road shoulder
- I = initial obstruction distance from road shoulder
- and N = number of obstructions on the transect.

If you assume in this example that the latter alternative was selected and that within the total transect length you counted 12 trees, the average spacing (OS) is computed to be $\frac{100-13}{11} = 8$ feet.

Step 6. Where the dominant type of obstruction is trees spaced an average of 8 feet apart, the protective strip should be 95 feet wide (table 3).

Step 7. To this add 24 feet because the soil is in group 6 (table 3, instruction 1).

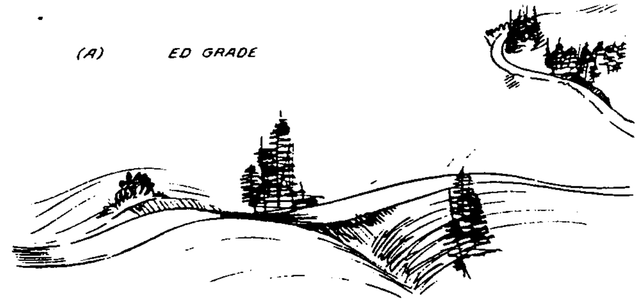
Step 8. The 49-foot cross-drain spacing (step 2) requires addition of 2 feet to the protective widths in table 3 (instruction 2).

Step 9. If distance to the first obstruction is 13 feet (step 4), 10 feet must be added to widths shown in table 3 (instruction 3).

cover immediately downslope from the staked locations of the cross-drain outlets. A[illegible]e here that for a particular cross drain the density of fill slope cover is 50 percent. This amount of cover permits reduction of 5 feet from the standard distances in table 3 (instruction 4).

Step 11. Note that the additions shown in steps 6 through 10 above result in 126 feet of protective strip width from the road centerline at the particular cross drain.

Since the actual width of the protective strip is 26 feet narrower than the required width, probably it will not prevent all sediment from reaching the stream. Hence, intensified control measures similar to those described above (pp. 25-29) are necessary at this location to reduce the probable sediment movement distance to less than the 100-foot width of the present strip.



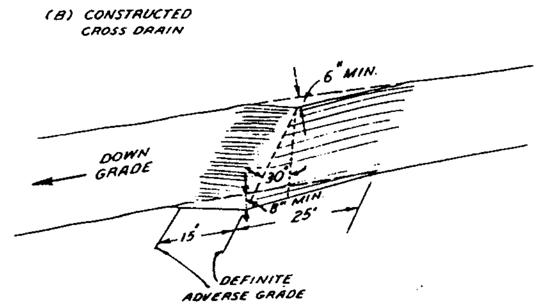


Figure 6.--Water diversions: A, rolled grade and B, constructed cross drain.

INSTALLING DEVICES TO CONTROL EROSION AND SEDIMENT FLOW

Mechanical measures or construction procedures are needed on logging roads to reduce soil erosion on road surfaces and fill slopes. Some of these prevent large quantities of water from accumulating on road surfaces by diverting water off the roads at specified intervals. Others prevent erosion of fill slopes and unstable natural slopes below roads by preventing water from reaching these slopes or by conveying water from road surfaces over these slopes to stable ground or to stream channels. The general specifications for installing these measures follow.

MEASURES FOR DIVERTING WATER OFF ROAD SURFACES

Rolled Grades

The preferred method of installing road surface drainage is to construct gentle rolling dips into the roadbed as the road is built (fig. 6A). This is called "rolling the grade." In constructing rolled grades it is essential that the dips be truly dips having an adverse slope on the downroad side. Drainage bottoms of the dips should slope gently downward from the toe of the road cut to the shoulder of the fill.

Cross Drains

Another effective method for diverting water off road surfaces is to construct cross drains in the roadbed immediately after logging and before the first fall rains or before the first winter. On roads open to passenger auto travel, cross drains must be designed to permit travel by modern sedans at speeds of 10 to 15 miles per hour. This requirement is met by cross drains having the following specifications (fig. 6B):

1. Excavated into the roadbed to minimum depths of 6 inches next to the cut bank and 8 inches at the road shoulder, with a definite adverse grade on the downroad or downgrade side of the cross drain.

2. Excavated material spread on the roadbed below the cross drain to a depth of not more than 3 inches.

3. Extending the full width of the road so that water in drains flows downhill from the toe of the cut bank to the road shoulder.

4. Tied into the cut bank at the upper end of the cross drain.

5. The long axis of the cross drain forming an angle of not less than 30° with a line across the road perpendicular to the centerline.

An open-top culvert is essentially a cross drain constructed of wood or sheet iron (fig. 7). It should be installed according to the same general specifications used for regular cross drains. Open-top culverts are suitable for use on secondary administrative roads but not for log haul roads.

Outsloping

Outsloping is simply uniformly grading the surface of a road so that it slopes downward across the road from the toe of the road cut to the road shoulder (fig. 8). All outsloped roads should have diversions in low sections to prevent the accumulation of water during wet weather. Outsloping is preferable for use on contour roads only.

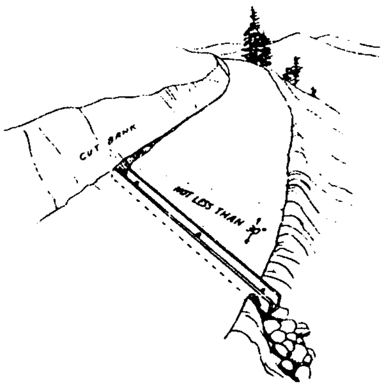


Figure 7.--Installing an open-top culvert.

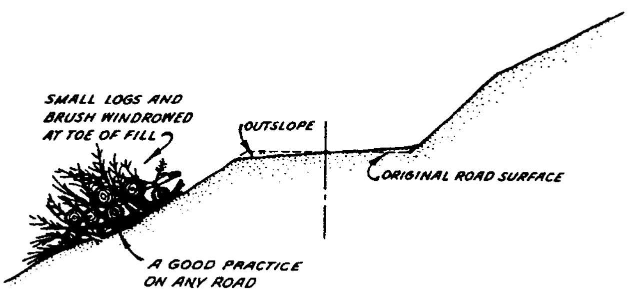


Figure 8.--Outsloping of contour roads.

Berms

Berms are earthen or soil cement dikes constructed along the shoulders of roads to prevent road surface water from draining onto fill slopes or unstable natural slopes. They must not be removed or damaged during road maintenance or snow removal. Berms should be constructed at least 30 inches wide at the base, 8 inches high, and 6 inches wide at the top (fig. 9).

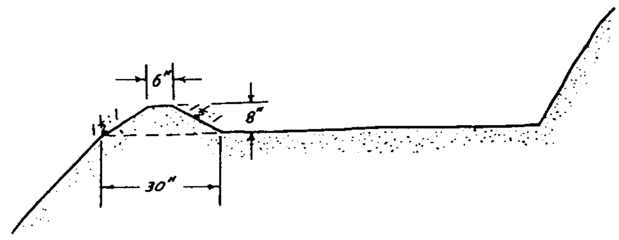


Figure 9.--Berm specifications.

Down Spouts

Down spouts are flumes, either open or enclosed, that convey water from the outlet of a road surface drainage structure downhill over fill slopes or other unstable areas to a stream channel (fig. 10). Their purpose is to prevent erosion of unstable slopes below roads by water diverted off road surfaces. They can be made of G.I. culvert, 1/2-round G.I. culvert, rock, masonry, soil cement, or treated lumber. It is important to install a concrete or rock apron at the lower end of down spouts to slow the water and prevent gouging of the stream channel.

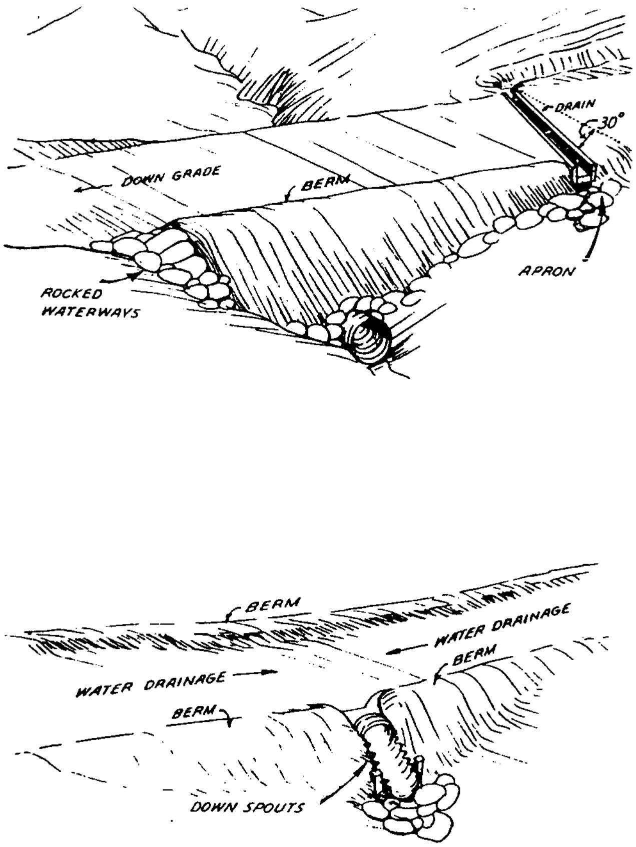


Figure 10.--Berms and down spouts to protect fill slopes.

FIFTEEN KEY RULES FOR REDUCING EROSION ON LOGGING ROADS

LOCATION AND DESIGN

1. All other factors being equal, roads located on south- and west-facing slopes require more intensive measures for preventing erosion than roads on north- and east-facing slopes.

2. Keep roads far enough away from streams.

3. Hold to low road grades.

4. Build the narrowest road that will do the jol consistent with safety.

5. Build water drainage structures as part of the road construction.

CONSTRUCTION AND MAINTENANCE

1. Complete the grading and drainage on all sections of newly built road before fall rains begin

2. Surface all roads built on highly erosive soils.

3. Do not allow low point of grade break to occur on deep fills if you can avoid it.

4. Leave berms on all deep fills.

5. Leave berms on climbing roads except at drainage outlets.

6. Construct down spouts over unstable fills and unstable natural slopes.

7. When maintaining roads, leave the toe of the cut slopes and the berms intact.

8. Where necessary, alter the spacing of surface drainage structures enough to spill the water on stable areas.

9. Install drainage diversion on outsloped roads.

10. Windrow unmerchantable logs and slash from road right-of-way timber along the toe of the fill slopes.

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